US009343928B2

(12) **United States Patent**
Bae

(10) **Patent No.: US 9,343,928 B2**
(45) **Date of Patent: May 17, 2016**

(54) **WIRELESS POWER TRANSMITTER, WIRELESS POWER RECEIVER, AND METHOD OF WIRELESSLY RECEIVING POWER**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 701 days.

(21) Appl. No.: **13/712,596**

(22) Filed: **Dec. 12, 2012**

(65) **Prior Publication Data**

US 2013/0229062 A1 Sep. 5, 2013

(30) **Foreign Application Priority Data**

Mar. 5, 2012 (KR) 10-2012-0022237

(51) **Int. Cl.**

H01F 27/42	(2006.01)
H02J 17/00	(2006.01)
H04B 5/00	(2006.01)
H02J 5/00	(2016.01)
H02J 7/02	(2016.01)

(52) **U.S. Cl.**
CPC ***H02J 17/00*** (2013.01); ***H02J 5/005*** (2013.01); ***H02J 7/025*** (2013.01); ***H04B 5/0037*** (2013.01); ***H04B 5/0081*** (2013.01)

(58) **Field of Classification Search**
USPC 307/104
See application file for complete search history.

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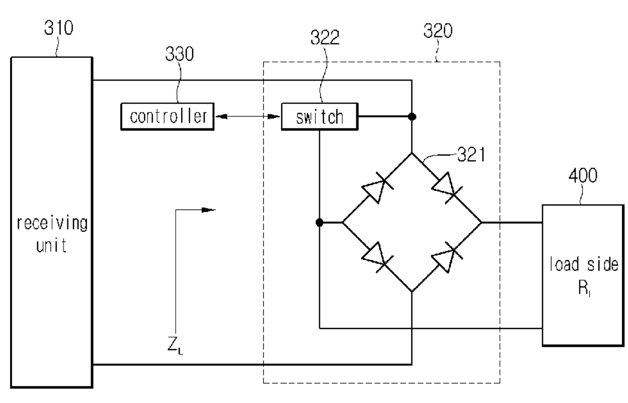
(57) **ABSTRACT**

Disclosed are a wireless power transmitter, a wireless power receiver, and a method of wirelessly receiving power. The wireless power receiver includes a receiving unit receiving the power from the wireless power transmitter using resonance, and a rectifying unit rectifying the power received therein from the receiving unit to supply the power to a load side. The rectifying unit changes an output impedance of the wireless power receiver in order to change an input current of the wireless power transmitter.

20 Claims, 5 Drawing Sheets



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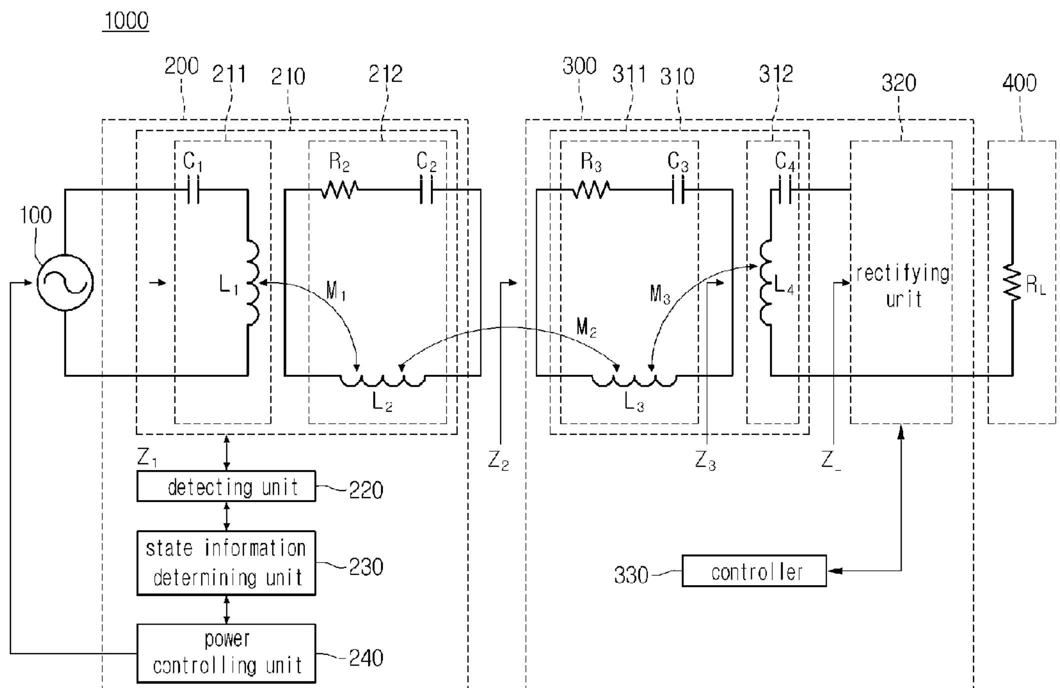

1000
200
211
210
212
300
311
310
312
320
400
100
C_1
R_2
C_2
R_3
C_3
C_4
L_1
M_1
L_2
M_2
L_3
M_3
L_4
rectifying unit
R_L
Z_1
Z_2
Z_3
Z_-
detecting unit
220
state information determining unit
230
power controlling unit
240
330
controller

FIG. 1

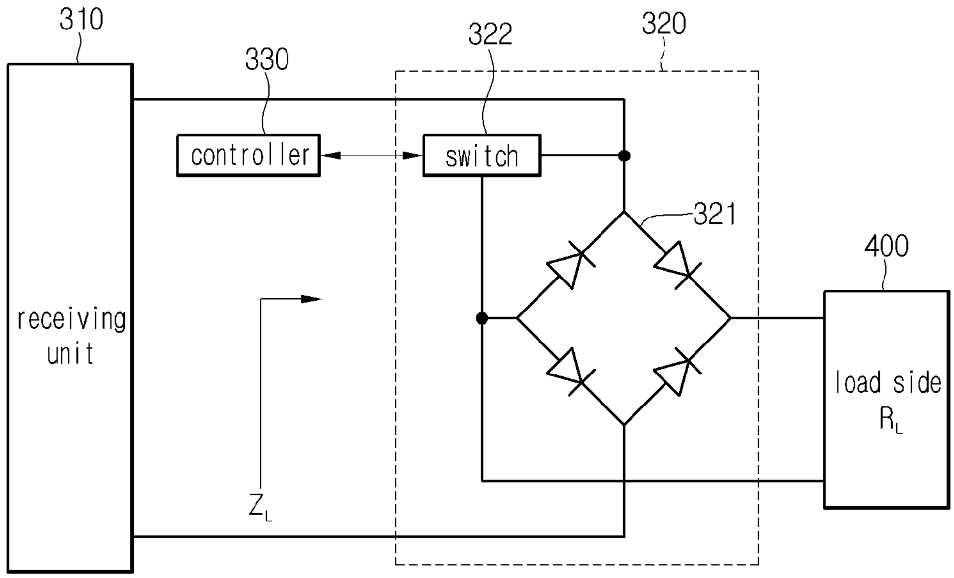

310
330
322
320
controller
switch
321
400
receiving unit
load side R_L
Z_L

FIG. 2

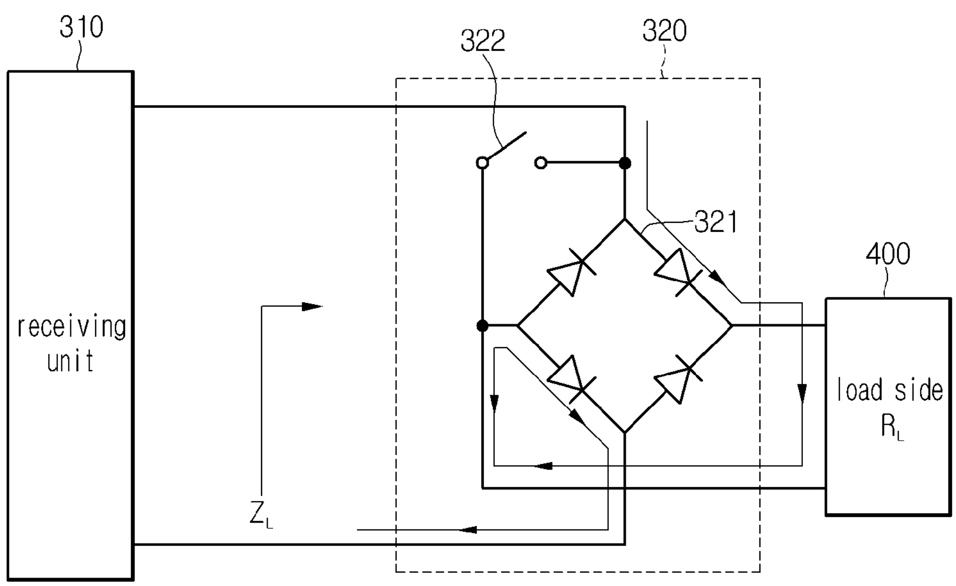

310
322
320
321
400
receiving unit
load side R_L
Z_L

FIG. 3

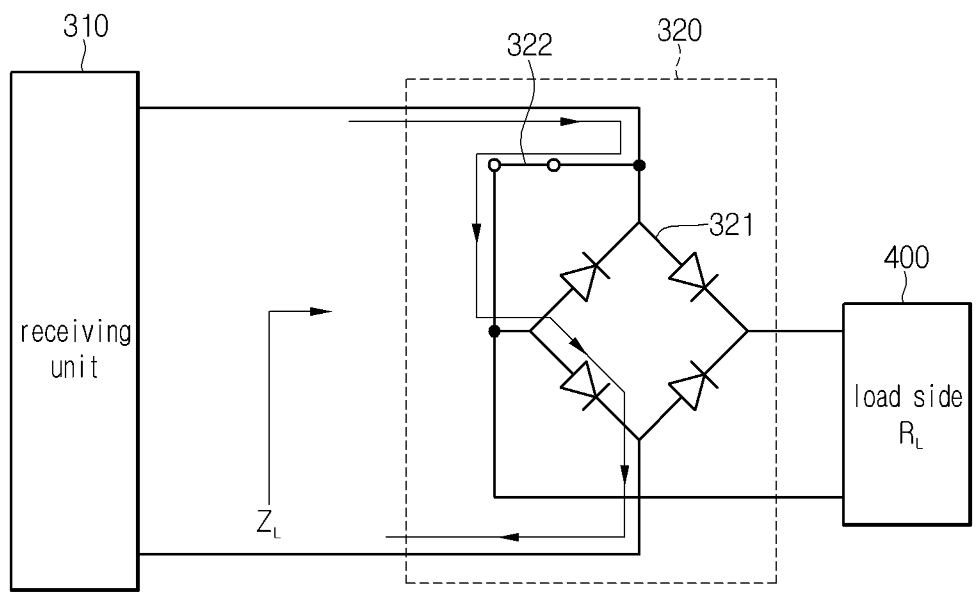


FIG. 4

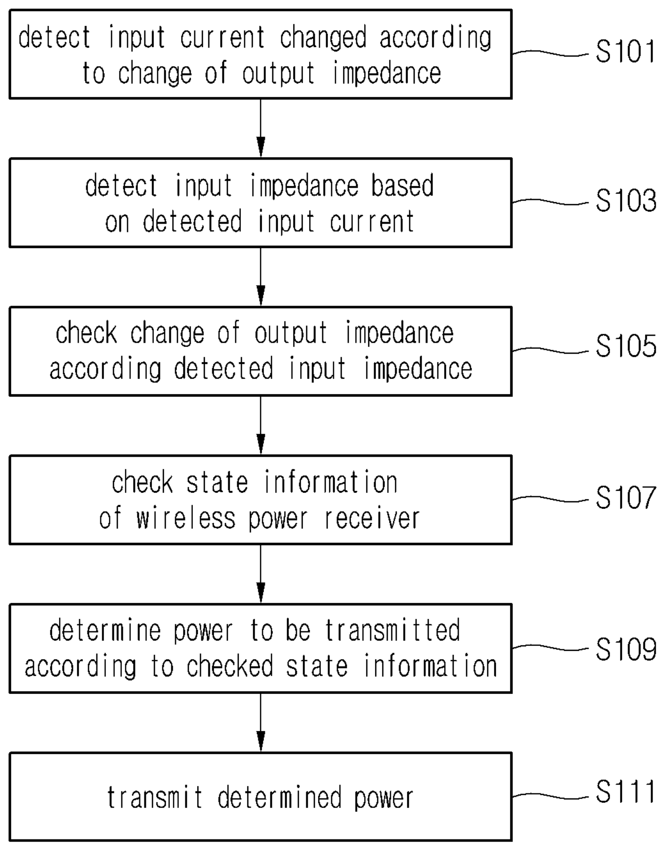
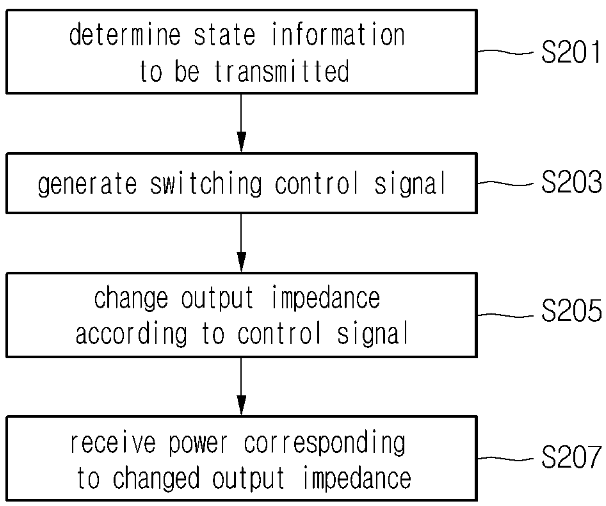

detect input current changed according to change of output impedance
S101
detect input impedance based on detected input current
S103
check change of output impedance according detected input impedance
S105
check state information of wireless power receiver
S107
determine power to be transmitted according to checked state information
S109
transmit determined power
S111

FIG. 5



determine state information to be transmitted
S201
generate switching control signal
S203
change output impedance according to control signal
S205
receive power corresponding to changed output impedance
S207

FIG. 6

WIRELESS POWER TRANSMITTER, WIRELESS POWER RECEIVER, AND METHOD OF WIRELESSLY RECEIVING POWER

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit under 35 U.S.C. §119 of Korean Patent Application No. 10-2012-0022237, filed Mar. 5, 2012, which is hereby incorporated by reference in its entirety.

BACKGROUND

The disclosure relates to a wireless power transmitter, a wireless power receiver, and a method of wirelessly receiving power.

A wireless power transmission or a wireless energy transfer refers to a technology of wirelessly transferring electric energy to desired devices. In the 1800's, an electric motor or a transformer employing the principle of electromagnetic induction has been extensively used and then a method for transmitting electrical energy by irradiating electromagnetic waves, such as radio waves or lasers, has been suggested. Actually, electrical toothbrushes or electrical razors, which are frequently used in daily life, are charged based on the principle of electromagnetic induction. Until now, the long-distance transmission using the magnetic induction, the resonance and the short-wavelength radio frequency has been used as the wireless energy transfer scheme.

Until now, wireless energy transmission schemes include a remote telecommunication technology based on resonance or a short wave radio frequency in addition to electromagnetic induction.

Recently, among wireless power transmitting technologies, an energy transmitting scheme employing resonance has been widely used.

In a wireless power transmission system employing resonance, since an electrical signal generated between the wireless power transmitter and the wireless power receiver is wirelessly transferred through coils, a user may easily charge electronic appliances such as a portable device.

In addition, the wireless power transmitter may receive information of a state of the wireless power receiver to transmit power. If the wireless power receiver includes an additional communication channel or an additional communication unit in order to transmit data to the wireless power transmitter, the high cost is required. Accordingly, the wireless power receiver mainly employs a load modulation scheme to transmit the data. According to the load modulation scheme, the wireless power receiver recognizes the change of an input impedance of the wireless power transmitter by changing the load (impedance) of the wireless power receiver.

However, the conventional load modulation scheme is limited to a magnetic induction type wireless power transmission system.

BRIEF SUMMARY

The disclosure provides a wireless power transmitter based on resonance capable of recognizing the information of a wireless power receiver by detecting input current, the wireless power receiver, and a method of receiving power.

The disclosure provides a wireless power transmitter based on resonance capable of recognizing the information of a wireless power receiver by detecting input current output

from a power source and comparing with the detected input current, the wireless power receiver, and a method of receiving power.

According to the embodiment, there is provided a wireless power receiver wirelessly receiving power from a wireless power transmitter. The wireless power receiver includes a receiving unit receiving the power from the wireless power transmitter using resonance, and a rectifying unit rectifying the power received therein from the receiving unit to supply the power to a load side. The rectifying unit changes an output impedance of the wireless power receiver in order to change an input current of the wireless power transmitter.

According to another embodiment, there is provided a wireless power transmitter wirelessly transmitting power to a wireless power receiver. The wireless power transmitter includes a transmission unit transmitting power, which is supplied from a power source, to the wireless power receiver using resonance, and a detecting unit detecting input current of the wireless power transmitter to detect a change of an output impedance of the wireless power receiver by using the detected input current.

According to still another embodiment, there is provided a method of receiving power of a wireless power receiver for wirelessly receiving the power from a wireless power transmitter. The method includes determining state information of the wireless power receiver to be transmitted to the wireless power transmitter, changing an output impedance of the wireless power receiver according to the determined state information, and receiving changed power from the wireless power transmitter according to the changed output impedance.

As described above, according to the embodiment, the change of the output impedance of the wireless power receiver is detected through the input current of the wireless power transmitter to detect the information of the wireless power receiver, so that the power can be effectively transmitted.

According to the embodiment, the wireless power receiver transmits the state information of the wireless power receiver to the wireless power transmitter by changing the output impedance, so that the wireless power receiver can receive power suitable for the state information thereof.

Meanwhile, any other various effects will be directly and implicitly described below in the description of the embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** a circuit diagram showing a wireless power transmission system according to the embodiment;

FIG. **2** is a view showing the structure of a rectifying unit according to one embodiment;

FIG. **3** is a view showing the open state of the switch of the rectifying unit **320** according to one embodiment;

FIG. **4** is a view showing the short state of the switch of the rectifying unit **320** according to one embodiment;

FIG. **5** is a flowchart showing the power transmission of the wireless power transmitter according to one embodiment; and

FIG. **6** is a flowchart showing a method of receiving power by the wireless power receiver according to one embodiment.

DETAILED DESCRIPTION

Hereinafter, the embodiments will be described with reference to accompanying drawings in detail so that those skilled in the art can easily realize the embodiments.

FIG. **1** a circuit diagram showing a resonance-type wireless power transmission system **1000** according to the embodiment.

Referring to FIG. **1**, the wireless power transmission system **1000** may include a power source **100**, a wireless power transmitter **200**, a wireless power receiver **300** and a load side **400**.

The wireless power transmitter **200** may include a transmitting unit **210**, a detecting unit **220**, a state information determining unit **230** and a power controlling unit **240**.

The transmitting unit **210** may includes a transmission induction coil unit **211** and a transmission resonance coil unit **212**.

The power generated from the power source **100** is transmitted to the wireless power transmitter **200**, and transmitted to the wireless power receiver **300** that makes resonance with the wireless power transmitter **200** through a resonance. The power received by the wireless power receiver **300** is transferred to the load side **400** through a rectifying unit **320**. The load side **400** may be a predetermined rechargeable battery or other devices requiring the power. According to the embodiment, a load resistor of the load side **400** is marked as reference sign R_L. According to the embodiment, the load side **400** may be included in the wireless power receiver **300**.

The power source **100** is an AC power source for supplying an AC power having a predetermined frequency.

The transmitting unit **210** may includes the transmission induction coil unit **211** and the transmission resonance coil unit **212**.

The transmission induction coil unit **211** is connected to the power source **100**, and AC current flows therethrough by the power received therein from the power source **100**. When the AC current flows through the transmission induction coil unit **211**, AC current is induced to the transmission resonance coil unit **212** physically spaced apart from the transmission induction coil unit **211** through an electromagnetic induction so that the AC current flows through the transmission resonance coil unit **212**. The power received by the transmission resonance coil **212** is transmitted to the wireless power receiver **300**, which forms a resonance circuit with the wireless power transmitter **200**, using resonance.

Power may be transmitted between two LC circuits, which are impedance-matched with each other, using resonance. The power transmitted by the resonance can be farther transmitted with higher efficiency when comparing with the power transmitted by the electromagnetic induction.

The transmission induction coil unit **211** includes a transmission induction coil L_1 and a capacitor C_1. In this case, the capacitance of the capacitor C_1 is an adjusted value so that the capacitor C_1 makes resonance at a resonance frequency ω.

One terminal of the capacitor C_1 is connected to one terminal of the power source **100**, and the other terminal of the capacitor C_1 is connected to one terminal of the transmission induction coil L_1. The other terminal of the transmission induction coil L_1 is connected to the other terminal of the power source **100**.

The transmission resonance coil unit **212** includes a transmission resonance coil L_2, a capacitor C_2, and a resistor R_2. The transmission resonance coil L_2 includes one terminal connected to one terminal of the capacitor C_2 and the other terminal connected to one terminal of the resistor R_2. The other terminal of the resistor R**2** is connected to the other terminal of the capacitor C_2. The resistance of the resistor R represents the quantity of power lost in the transmission resonance coil L**2**. In this case, the capacitance of the capacitor C_2 is an adjusted value so that the capacitor C_2 makes resonance at a resonance frequency ω.

The detecting unit **220** may measure a first input impedance Z_1. According to one embodiment, the first input impedance Z_1 is obtained when seen from the power source **100** toward the wireless power transmitter **200**.

According to the embodiment, the detecting unit **220** may detect the first input impedance Z_1 by detecting current input to the wireless power transmitter **200**. In detail, on the assumption that voltage input to the wireless power transmitter **200** is constant, the detecting unit **220** may detect the first input impedance Z_1 by an equation, Z=V/I, used to find an impedance after detecting the current input to the wireless power transmitter **200**.

The detecting unit **220** may detect the average current input to the wireless power transmitter **200**, and the average input current may refer to an average value of the current input to the wireless power transmitter **200** during one cycle. The average input current may be varied by the rectifying unit **320** of the wireless power receiver **300** which will be described later.

The detecting unit **220** may detect the change of the output impedance of the wireless power receiver **300** by using the measured average input current.

The state information determining unit **230** determines the state information of the wireless power receiver **300** based on the change of the output impedance. According to one embodiment, the state information of the wireless power receiver **300** may include the information of the present quantity of power charged in the wireless power receiver **300** or the information of the quantity of power corresponding to the variation in the quantity of power charged in the wireless power receiver **300**. According to one embodiment, the state information of the wireless power receiver **300** may include power charge completion information representing that the wireless power receiver **300** has been completely charged with power.

The power controlling unit **240** controls power to be transmitted to the wireless power receiver **300** according to the state information of the wireless power receiver **300**.

The power controlling unit **240** controls the power source **100** so the power to be transmitted to the wireless power transmitter **200** can be controlled. Accordingly, the power to be transmitted to the wireless power receiver **300** can be controlled.

Accordingly, the procedure of detecting the average input current output by the power source **100** may refer to the procedure in which the wireless power transmitter **200** determines the state of the wireless power receiver **300**. In other words, the wireless power receiver **300** transmits the state information thereof to the wireless power transmitter **200**, and the wireless power transmitter **200** can transmit desirable power to the wireless power receiver **300** by using the state information of the wireless power receiver **300**.

The wireless power transmitter **200** detects the information of the present quantity of power charged in the wireless power receiver **300** based on the average input current output from the power source **100** to transmit power corresponding to the above information.

The wireless power receiver **300** may include a receiving unit **310** and the rectifying unit **320**.

The wireless power receiver **300** may be embedded in an electronic device such as a cellular phone, a mouse, a laptop computer, and an MP3 player.

The receiving unit **310** includes a reception resonance coil unit **311** and a reception induction coil unit **312**.

The reception resonance coil unit **311** includes a reception resonance coil L_3, a capacitor C_3, and a resistor R_3. The reception resonance coil L_3 includes one terminal connected to one terminal of the capacitor C_3 and the other terminal connected to one terminal of the resistor R_3. The other terminal of the resistor R_3 is connected to the other terminal of the capacitor C_2. The resistance of the resistor R_3 represents the quantity of power lost in the reception resonance coil L**3**. In this case, the capacitance of the capacitor C_3 is adjusted by a controller **330** so that the capacitor C_3 makes resonance at a resonance frequency w.

The reception induction coil unit **312** may include a reception induction coil L_4 and a capacitor C_4. One terminal of the reception induction coil L_4 is connected to one terminal of the capacitor C_4, and the other terminal of the reception induction coil L_4 is connected to the other terminal of the rectifying unit **320**. The other terminal of the capacitor C_4 is connected to one terminal of the rectifying unit **320**. The capacitance of the capacitor C_4 is adjusted by the controller **330** so that the capacitor C_4 makes resonance at a resonance frequency w.

The reception resonance coil unit **311** maintains the resonance state with the transmission resonance coil unit **212** at the resonance frequency. In other words, the reception resonance coil unit **311** is coupled with the transmission resonance coil unit **212** such that an AC current flows through the reception resonance coil unit **311**, and the wireless power receiver **300** may receive power from the wireless power transmitter **200** in a non-radiative scheme.

The reception induction coil unit **312** receives power from the reception resonance coil unit **311** by electromagnetic induction, and the power received by the reception induction coil unit **312** is transmitted to the load side **400** after the power is rectified by the rectifier circuit **320**.

The rectifying unit **320** receives the AC power from the reception induction coil unit **312** and rectifies the received AC power so that the AC power is converted into DC power.

The rectifying unit **320** may vary the output impedance Z_L obtained when seen from the reception induction coil unit **312** toward the load side **400**. According to one embodiment, the output impedance Z_L may refer to the impedance obtained when seen from the reception induction coil unit **312** toward the rectifying unit **320**.

The rectifying unit **320** varies the output impedance Z_L through the open or the short of the switch SW, so that the first input impedance Z_1 can be changed. Hereinafter, the change of the average input current output by the power source **100** according to the first input impedance Z_1 changed by the rectifying unit **320** will be described.

The third input impedance Z_3 may refer to an impedance measured when the load side **400** is seen from the reception resonance coil L_3 and may be expressed by Equation 1:

$$Z_3 = \frac{\omega^3 M_3^2}{Z_L + j\omega L_4 + \frac{1}{j\omega C_4}} \quad \text{Equation 1}$$

In this case, ω denotes a resonance frequency when the transmission resonance coil L_2 makes resonance with the reception resonance coil L_3, and M_3 denotes is a mutual inductance between the reception resonance coil L_3 and the reception induction coil L_4. Further, Z_L denotes output impedance.

Equation 1 is an equation based on a frequency domain, and even following equations are expressed based on the frequency domain.

The second input impedance Z_2 means an impedance measured when the wireless power receiver **300** is seen from the wireless power transmitter **200**, and may be expressed as Equation 2:

$$Z_2 = \frac{j\omega^2 C_3 M_2^2}{1 - \omega^2 L_3 C_3 + j\omega C_3 (Z_3 + R_3)} \quad \text{Equation 2}$$

In this case, M_2 denotes a mutual inductance between the transmission resonance coil L_2 and the reception resonance coil L**3**, and C**3** denotes a capacitor expressed when the reception resonance coil unit **311** is transformed to equivalent circuit. In addition, the resistance of the resistor R**3** represents the quantity of power lost in the reception resonance coil **13**.

While the capacitor C_3 and the leakage resistor R_3 may have fixed values, the mutual inductance M_2 may be varied with a coupling coefficient K_2 between the transmission resonance coil L_2 and the reception resonance coil L_3.

The coupling coefficient K_2 represents a degree of the electromagnetic couple between the transmission resonance coil L_2 and the reception resonance coil L_3, and may be varied by at least one of a distance, a direction and a position between the wireless power transmitter **200** and the wireless power receiver **300** in the wireless power system **1000**.

The first input impedance Z**1** is an impedance measured when seen the wireless power transmitter **200** from the power source **100** and may be expressed as Equation 3:

$$Z_1 = j\omega L_1 + \frac{1}{j\omega C_1} + \frac{j\omega^3 C_2 M_1^2}{1 - \omega^2 L_2 C_2 + j\omega C_2 (Z_2 + R_2)} \quad \text{Equation 3}$$

In this case, M_1 represents a mutual inductance between the transmission induction coil L_1 and the transmission resonance coil L_2.

On the assumption that R**1** and R**2** have very small values in Equations 1 to 3, R_1 and R_2 may become '0'(zero). In addition, if a resonance frequency ω is determined such that resonances between the transmission induction coil L_1 and the capacitor C_1, between the transmission resonance coil L_2 and the capacitor C_2, and between the reception resonance coil L_3 and the capacitor C_3 occur at the resonance frequency ω, the first input impedance Z_1 may be expressed as Equation 4.

$$Z_1 = \frac{M_1^2 M_3^2}{M_2^2} \frac{\omega^2}{Z_L} \quad \text{Equation 4}$$

Further, if following Equation 5 to Equation 7, which represent the relation between mutual inductances and coupling coefficients, are applied to Equation 4, Equation 4 may be expressed as Equation 8.

$$M_1 = k_1\sqrt{L_1 L_2} \quad \text{Equation 5}$$

In this case, a coupling coefficient K**1** refers to the degree of the electromagnetic coupling between the transmission induction coil L_1 and the transmission resonance coil L_2, and M_1 refers to the mutual inductance between the transmission induction coil L_1 and the transmission resonance coil L_2.

$$M_2 = K_2\sqrt{L_2 L_3} \quad \text{Equation 6}$$

In Equation 6, a coupling coefficient K**2** refers to the degree of the electromagnetic coupling between the transmission resonance coil L_2 and the reception resonance coil L_3, and M_2 refers to the mutual inductance between the transmission resonance coil L_2 and the reception resonance coil L_3.

$$M_3 = K_3\sqrt{L_3 L_4} \quad \text{Equation 7}$$

In Equation 7, a coupling coefficient K_3 refers to the degree of the electromagnetic coupling between the reception resonance coil L_3 and the reception induction coil L_4, and M_3 refers to the mutual inductance between the reception resonance coil L_3 and the reception induction coil L4.

$$Z_1 = \frac{k_1^2 k_3^2}{k_2^2} \frac{\omega^2 L_1 L_4}{Z_L} \quad \text{Equation 8}$$

As a result, regarding Equation 8, the first input impedance Z_1 may be changed as the output impedance Z_L is changed. Since the input current, which is output from the power source **100**, may be expressed as the ratio of input voltage to the first input impedance Z_1, the input current may be changed as the first input impedance Z_1 is changed. The details thereof will be more described with reference to FIGS. **2** to **4**.

The controller **330** may control the rectifying unit **320** by applying a control signal to the rectifying unit **320**. The control signal may be used to open or short the switch SW.

Hereinafter, the change of the output impedance Z_L and the first input impedance Z_1 according to the open or the short of the switch SW will be described with reference to FIGS. **2** to **3**. In this case, the load modulation is performed through the change of the first input impedance Z_1.

FIG. **2** is a view showing the structure of the rectifying unit **320** according to one embodiment.

Referring to FIG. **2**, the rectifying unit **320** includes a bridge diode **321** and a switch **322**.

The rectifying unit **320** may rectify AC power, which is received therein from the receiving unit **310**, to DC power to be transmitted to the load side **400**.

The bridge diode **321** has a structure in which four diodes are connected to each other. The bridge diode **321** rectifies AC current to be transmitted to the load side **400** into DC current so that the DC current may be transmitted to the load side **400**.

The switch **322** is opened or shorted depending on the control signal of the controller **330** to change the flow of current to be transmitted to the load side **400**.

Hereinafter, the change of the first input impedance Z_1 according to the change of the output impedance Z_1 in the open state or the short state of the switch **322** will be described.

FIG. **3** is a view showing the open state of the switch **322** of the rectifying unit **320** according to one embodiment.

Referring to FIG. **3**, if the switch **322** is opened by the control signal of the controller **330**, the rectifying unit **320** may be expressed as a circuit shown in FIG. **3**.

If the switch **322** is opened, the output impedance Z_L may be expressed as Equation 9. In other words, if the switch **322** is opened, the bridge diode **321** may change the flow of current input from the receiving unit **310** to the bridge diode **321**. In detail, if the switch **322** is opened, the current flows along the arrow shown in FIG. **3**.

In this case, the output impedance Z_L may be expressed as Equation 9.

$$Z_L = R_L \quad \text{Equation 9}$$

The first input impedance Z_1 may be expressed as Equation 10 by substituting Equation 9 into Equation 8.

$$Z_1 = \frac{k_1^2 k_3^2}{k_2^2} \frac{\omega^2 L_1 L_4}{R_L} \quad \text{Equation 10}$$

FIG. **4** is a view showing the short state of the switch **322** of the rectifying unit **320** according to one embodiment.

Referring to FIG. **4**, if the switch **322** is shorted by the control signal of the controller **330**, the rectifying unit **320** may be expressed as a circuit shown in FIG. **4**.

If the switch **322** is shorted, current may flow along the arrow shown in FIG. **4**, and the output impedance ZL may be expressed as Equation 11.

$$Z_L = 0 \quad \text{Equation 11}$$

In other words, during one cycle in which the switch **322** is shorted, the output impedance ZL may be expressed as Equation 11. In addition, during one cycle in which the switch **322** is opened, the output impedance Z_L may be expressed as Equation 9. In other words, if the switch **322** is shorted, the bridge diode **321** changes the flow of current input from the receiving unit **310** to the bridge diode **321**, so that the output impedance Z_L during one cycle may be expressed as Equation 11. If the switch **322** is opened, the bridge diode **321** changes the flow of the current input therein from the receiving unit **310**, so that the output impedance Z_L during another cycle may be expressed as Equation 9.

Accordingly, during one cycle in which the switch **322** is opened, the first input impedance Z_1 may be expressed as Equation 10. During another cycle in which the switch **322** is shorted, the first input impedance Z_1 may be expressed as Equation 12.

$$Z_1 = \frac{k_1^2 k_3^2}{k_2^2} \frac{\omega^2 L_1 L_4}{0} = \infty \quad \text{Equation 12}$$

The first input impedance Z_1 may be obtained as the ratio of input voltage, which is output from the power source **100**, to input current. As the switch **322** is opened or shorted as described above, the first input impedance Z_1 is varied. As the first input impedance Z_1 is varied, the input current output from the power source **100** is varied. In this case, on the assumption that the input voltage output from the power source **100** is previously known, the detecting unit **220** may detect the first input impedance Z1 of the wireless power transmitter **200** by measuring the input current input to the wireless power transmitter **200**. In detail, the detecting unit **220** may measure the input current input to the wireless power transmitter **200** in the unit of a cycle, and detect the first input impedance Z_1 based on the measured input current.

The detecting unit **220** may detect the change of the output impedance of the wireless power receiver **300** based on the first input impedance Z_1.

Accordingly, the open state or the short state of the switch **322** can be recognized by comparing with the average input current output from the power source **100** or the first input impedance Z1 during one cycle. Therefore, the wireless power transmitter **200** may detect the state of the wireless power receiver **300** to transmit desirable power according to the detected state of the wireless power receiver.

For example, when the wireless power receiver **300** transmits digital data of 1 to the wireless power transmitter **200**, the controller **330** may short the switch **322**. In addition, when the wireless power receiver **300** transmits digital data of 0, the controller **330** may open the switch **322**. Naturally, the above description is made only for the illustrative purpose. In other words, when the wireless power receiver **300** transmits digital data of 1 to the wireless power transmitter **200**, the controller **330** may open the switch **322**. In addition, when the wireless power receiver **300** transmits digital data of 0, the controller **330** may short the switch **322**.

The detecting unit **220** may check the short state or the open state of the switch **322** through the detection and the comparison of the average input current of the wireless power transmitter **200** or the first input impedance Z_1 so that the state information of the wireless power receiver **300** can be received.

Accordingly, the wireless power transmitter **200** can transmit desirable power by receiving the state information of the wireless power receiver **300**.

For example, when the wireless power receiver **300** transmits the power charge completion information, which represents that the wireless power receiver **300** has been completely charged with power, to the wireless power transmitter **200**, the wireless power receiver **300** performs a switching operation corresponding to the power charge completion information, and the wireless power transmitter **200** detects the average input current or the first input impedance Z_1 to receive the power charge completion information of the wireless power receiver **300**. The wireless power transmitter **200** controls the power source **100** according to the received power charge completion information to stop the power transmission to the wireless power receiver **300**.

FIG. **5** is a flowchart showing the power transmission of the wireless power transmitter according to one embodiment.

Hereinafter, the power transmission of the wireless power transmitter according to one embodiment will be described with reference to FIGS. **1** to **4**.

First, the detecting unit **220** of the wireless power transmitter **200** detects the input current of the wireless power transmitter **200** changed as the output impedance of the wireless power receiver **300** is changed (step S**101**). The input current may be output from the power source **100** and then input to the wireless power transmitter **200**. The detecting unit **220** may detect the input current during one cycle. One cycle may be time in which the switch **322** of the wireless power receiver **300** maintains a short state or an open state.

In other words, the rectifying unit **320** of the wireless power receiver **300** may vary the output impedance Z_L. Accordingly, the input current of the wireless power transmitter **200** may be varied. In detail, the controller **330** may vary the output impedance Z_L by transmitting the control signal to the switch **322** of the rectifying unit **320**. In other words, the wireless power receiver **300** may vary the output impedance Z_L in order to transmit the state information thereof to the wireless power transmitter **200**. The control signal may be a signal to open or short the switch **322**. The procedure of varying the output impedance Z_L has been described above with reference to FIGS. **1** to **4**.

According to one embodiment, the output impedance Z_L may be impedance measured when seen from the receiving unit **310** to the rectifying unit **320**.

Thereafter, the detecting unit **220** of the wireless power transmitter **200** detects the input impedance of the wireless power transmitter **200** based on the input current detected by the detecting unit **220** (step S**103**). On the assumption that the input voltage of the wireless power transmitter **200** is constant, the detecting unit **220** may detect the input impedance of the wireless power transmitter **200** based on the input current detected through the equation related to the impedance, Z=V/I. The input impedance of the wireless power transmitter **200** is the first input impedance described with reference to FIGS. **1** to **4**.

The detecting unit **220** of the wireless power transmitter **200** may check the change of the output impedance of the wireless power receiver **300** by using the detected input impedance of the wireless power transmitter **200** (step S**105**). According to one embodiment, the detecting unit **220** may recognize the change of the output impedance by comparing the input impedance during one present cycle with the input impedance detected during one previous cycle. In other words, the input impedance may be varied in the unit of one cycle according to the switching operation of the wireless power receiver **300**, and the detecting unit **220** may check the change of the output impedance based on the input impedance of each cycle.

The state information determining unit **230** of the wireless power transmitter **200** determines the state information of the wireless power receiver **300** based on the checked change of the output impedance (step S**107**).

In other words, since changing the output impedance is a procedure in which the wireless power receiver **300** transmits the state information of the wireless power receiver **300** to the wireless power transmitter **300**, the state information determining unit **230** can check the state information of the wireless power receiver **300** based on the change of the output impedance.

The power controlling unit **240** of the wireless power transmitter **200** can determine the quantity of power to be transmitted to the wireless power receiver **300** according to the checked state information of the wireless power receiver **300**, and control the power source **100** to supply the determined quantity of the transmission power to the wireless power receiver **300** (step S**109**).

The transmitting unit **210** of the wireless power transmitter **200** transmits the determined quantity of the transmission power to the wireless power receiver **300** (step S**111**).

FIG. **6** is a flowchart showing a method of receiving power by the wireless power receiver according to one embodiment.

Hereinafter, the method of receiving power by the wireless power receiver according to one embodiment will be described based on the description made with reference to FIGS. **1** to **4**.

The controller **330** of the wireless power receiver **300** determines the state information of the wireless power receiver **300** to be transmitted to the wireless power transmitter **200** (step S**201**). In other words, the wireless power receiver **300** may create and determine the state information to be transmitted in order to inform the wireless power transmitter **200** of the present state of the wireless power receiver **300** to be transmitted.

According to one embodiment, the state information of the wireless power receiver **300** may include one of power charge completion information representing that the wireless power receiver **300** has been completely charged with power, the information of the present quantity of power or the quantity of power corresponding to the variation in the quantity of power which is charged in the wireless power receiver **300**, and charge state information representing that the wireless power receiver **300** normally receives power.

The controller **330** of the wireless power receiver **300** creates a switching control signal to control the operation of the switch **322** of the rectifying unit **320** according to the determined state information of the wireless power receiver **300** (step S**203**).

The rectifying unit **320** of the wireless power receiver **300** changes the output impedance of the wireless power receiver **300** according to the created control signal (step S**205**). The control signal may include a short signal or an open signal to change the output impedance of the wireless power receiver **300**. The procedure of changing the output impedance has been described with reference to FIGS. **1** to **4**.

According to one embodiment, the output impedance Z_L may represent an impedance measured when seen from the receiving unit **310** of the wireless power receiver **300** to the rectifying unit **320**.

The wireless power receiver **300** informs the wireless power transmitter **200** of the state information of the receiving unit **310** and receives power corresponding to the state information (step S**205**). According to one embodiment, the wireless power receiver **300** may inform the wireless power transmitter **200** of the state information of the wireless power receiver **300** by changing the output impedance so that the transmission power is increased, and the receiving unit **310** may receive the increased power.

According to one embodiment, the wireless power receiver **300** may inform the wireless power transmitter **200** of the state information of the wireless power receiver **300** representing that power changing is completed by changing the output impedance, and the receiving unit **310** may not receive power from the wireless power transmitter **200**.

A power transmission method and a power reception method according to the disclosure may be prepared as a program executable by a computer and stored in computer-readable recording media. The computer-readable recording media include a ROM, a RAM, a CD-ROM, a magnetic table, a floppy disk, and an optical data storing device, and include a device realized in the form of a carrier wave (for example, transmission over the Internet).

The computer-readable recording media are distributed into computer systems connected to each other through a network to store computer-readable codes through a distribution scheme so that the computer-readable codes may be executed. In addition, function programs, codes, and code segments used to realize the method can be easily deduced by programmers in the art to which the disclosure pertains.

Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

What is claimed is:

1. A wireless power receiver wirelessly receiving power from a wireless power transmitter, the wireless power receiver comprising:

a receiving unit receiving the power from the wireless power transmitter using resonance; and

a rectifying unit rectifying the power received therein from the receiving unit to supply the power to a load side,

wherein the rectifying unit changes an output impedance of the wireless power receiver in order to change an input current of the wireless power transmitter,

wherein the rectifying unit comprises:

a bridge diode comprising four diodes connected to each other; and

a switch changing a flow of current inputted from the receiving unit to the bridge diode,

wherein the bridge diode changes the output impedance as the toy of current is changed.

2. The wireless power receiver of claim **1**, wherein the switch is opened or shorted in order to change the flow of current.

3. The wireless power receiver of claim **2**, wherein the output impedance is an impedance measured when seen from the receiving unit to the rectifying unit.

4. The wireless power receiver of claim **1**, wherein the output impedance is an impedance measured when seen from the receiving unit to the rectifying unit.

5. The wireless power receiver of claim **1**, wherein the rectifying unit informs the wireless power transmitter of state information of the wireless power receiver as the input current of the wireless power transmitter is changed by changing the output impedance.

6. The wireless power receiver of claim **5**, wherein the state information of the wireless power receiver includes one of power charge completion information of the wireless power receiver and a quantity of power charged in the wireless power receiver.

7. The wireless power receiver of claim **1**, wherein the receiving unit comprises:

a reception resonance coil resonance-coupled with a transmission resonance coil of the wireless power transmitter to receive the power; and

a reception induction coil coupled with the reception resonance coil to receive the power.

8. A wireless power transmitter wirelessly transmitting power to a wireless power receiver, the wireless power transmitter comprises:

a transmission unit transmitting power, which is supplied from a power source, to the wireless power receiver using resonance; and

a detecting unit detecting input current of the wireless power transmitter to detect a change of an output impedance of the wireless power receiver by using the detected input current,

wherein the wireless power receiver changes the output impedance in order to change the input current,

wherein the wireless power receiver comprises:

a bridge diode comprising four diodes connected to each other; and

a switch changing a flow of current inputted to the bridge diode,

wherein the bridge diode changes the output impedance as the flow of current inputted to the bridge diode is changed.

9. The wireless power transmitter of claim **8**, wherein the input impedance is an impedance measured when seen from the power source toward the wireless power transmitter.

10. The wireless power transmitter of claim **8**, wherein the detecting unit detects the change of the output impedance of the wireless power receiver by detecting an average input current of the wireless power receiver during one cycle.

11. The wireless power transmitter of claim **8**, wherein the transmission unit comprises:

a transmission induction coil receiving the power from the power source; and

a transmission resonance coil coupled with the transmission induction coil to transmit the received power to the wireless power receiver using resonance.

12. The wireless power transmitter of claim **8**, further comprising a state information determining unit to determine state information of the wireless power receiver based on the detected change of the output impedance.

13. The wireless power transmitter of claim **12**, further comprising a power controlling unit to control the power to be transmitted to the wireless power receiver according to the determined state information.

14. The wireless power receiver of claim **8**, wherein the output impedance is an impedance measured when seen from a receiving unit of the wireless power receiver to a rectifying unit including the bridge diode and the switch.

15. A method of receiving power of a wireless power receiver for wirelessly receiving the power from a wireless power transmitter, the method comprising:

determining state information of the wireless power receiver to be transmitted to the wireless power transmitter;

changing an output impedance of the wireless power receiver according to the determined state information; and

receiving changed power from the wireless power transmitter according to the changed output impedance,

wherein the wireless power receiver comprises:

a bride diode comprising four diodes connected to each other; and

a switch changing a flow of current inputted to the bridge diode,

wherein the bridge diode changes the output impedance as the flow of current inputted to the bridge diode is changed.

16. The method of claim **15**, wherein the switch is opened or shorted in order to change the flow of current inputted to the bridge diode.

17. The method of claim **15**, wherein the receiving of the changed power from the wireless power transmitter according to the changed output impedance comprises:

changing an input current of the wireless power transmitter as the output impedance is changed and

receiving the changed power from the wireless power transmitter based on the changed input current.

18. The method of claim **15**, wherein the state information of the wireless power receiver includes one of power charge completion information of the wireless power receiver and a quantity of power charged in the wireless power receiver.

19. The method of claim **15**, wherein the output impedance of the wireless power receiver is an impedance measured when seen from a receiving unit provided in the wireless power receiver toward a rectifying unit including the bridge diode and the switch.

20. A recording medium recording a program for executing the method for receiving a power of the wireless power receiver claimed claim **15**.

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